Research Report on a Hayward Residential Energy Conservation Ordinance (RECO)

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Prepared for:
Mayor and City Council Sustainability Committee
City of Hayward

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Executive Summary

The Hayward Climate Action Plan, adopted on July 28, 2009, recommends the adoption of a Residential Energy Conservation Ordinance that would require residential energy improvements in existing buildings. City Council Sustainability Committee meetings held this year on February 3rd and June 2nd presented major elements of a possible RECO, and the kinds of options and choices associated with each of them. The purpose of this report is to answer key questions that will inform the development of a RECO:

- What retrofit measures make sense to consider in Hayward, and what do they cost?
- How much energy do these measures save annually, and are they cost-effective?
- What is the amount of greenhouse gas reduction that results from specific retrofit measures for an individual dwelling? And what is the aggregate greenhouse gas reduction if measures are implemented citywide?
- How do the potential criteria that might trigger an ordinance such as remodels, point-of-sale and date certain (explained in Section 6) affect how the City is able to meet its Climate Action Plan goals?

The approach used to answer these questions includes a mix of existing research data, utility energy use data and original analysis with building energy software.

Costs and Cost-Effectiveness

Individual retrofit measures such as duct sealing, attic insulation, air sealing and new gas tank water heater cost on average in the range of $1,000 to $1,600. A combination of air sealing plus either attic insulation or duct sealing or R-19 floor insulation cost on average in the range of $2,400 to $3,000. Air sealing + attic insulation + duct sealing cost on average in the range of $3,600 to $3,900. Other measures – usually a combination of four or more individual measures – can average from $4,000 to $8,000 as shown in Tables 2a and 2b in Section 4 of this report.

Table 1 below shows the typical range of paybacks with and without potential utility and tax incentives based on the combination of installed cost and annual energy cost savings for each retrofit measure or set of measures. The table is very conservative in that is assumes no increased resale value of the house as a result of the energy improvements. With no incentives, paybacks range from 25 to 34 years for all measures except air sealing + floor insulation (36 years) and new gas water heaters (42 to 58 years). If incentives are included, paybacks for all measures except water heaters range from 8 to 24 years.

If an increase in resale value from energy improvements is accounted for, paybacks are reduced accordingly. For example, if 30% of the retrofit cost accrues to the resale value, paybacks without incentives are also reduced 30% the range of 17 to 25 years (excluding water heaters).

Table 1. Cost and Cost-Effectiveness of Retrofit Measures

Energy Retrofit Measures	Average Retrofit Cost ($)	Average Payback with No Incentives (Years)	Net Retrofit Cost with Incentives ($)	Average Payback with Incentives (Years)
Duct Sealing	$1,029	27.8	$415	11.2
R-30 Attic (from R-0)	$1,178	24.6	$1,028	21.5
R-38 Attic (from R-0)	$1,319	27.0	$1,169	23.9
Gas Water Heater EF=0.58	$1,400	58.1	$1,400	58.1
Air Sealing	$1,411	33.9	$706	16.9
Gas Water Heater EF=0.62	$1,625	41.8	$1,625	41.8
Air Sealing + Duct Sealing	$2,440	31.0	$1,220	15.5
Air Sealing + R-30 Attic	$2,589	29.1	$1,589	17.8
Air Sealing + R-38 Attic	$2,828	31.2	$1,414	15.6
Air Sealing + R-19 Raised Floor	$3,016	36.2	$1,508	18.1
Air Sealing + R-30 Attic + Duct Sealing	$3,617	31.1	$1,809	15.6
Air Sealing + R-38 Attic + Duct Sealing	$3,856	32.7	$928	7.9

Selected Energy Retrofit Measures

As covered with Table 2b in Section 4 of this report, several combinations of measures

(a) have an installed cost at or below $3,000; and

(b) have a simple payback without any incentives around 30 to 35 years; and

(c) reduce greenhouse gases in the range of 8% to 9%; and

(d) improve the Home Energy Rating System (HERS 2) score of the existing house by more than 10% (explained in Section 3).

The retrofit combinations which that these criteria appear to be appropriate for consideration as required improvements:

(1) Air Sealing + R-30 Attic Insulation (from no insulation)

(2) Air Sealing + Duct Sealing

(3) Air Sealing + R-19 Raised Floor Insulation (from no insulation)

RECO Recommendations

A review of the report analysis and data suggests a RECO that

- Gives the individual homeowner flexibility through several prescriptive choices as well as a performance option in meeting the RECO requirements;
- Promotes retrofit measures with quality assurance that are cost-effective in securing energy savings even without utility or other incentives;
- Achieves citywide reductions in greenhouse gas emissions in line with the Hayward Climate Action Plan 2050 Single Family/Duplex RECO targets.

A RECO would include a list of *Mandatory Features*, *Compliance Options* (prescriptive or performance), a *Cost Cap*, and a combination of *Triggers* to reach the City's greenhouse gas reduction goals.

Mandatory Features

Research done for other Bay Area RECOs indicates that a set of relatively inexpensive measures which are cost-effective would be appropriate as minimum requirements for a Hayward RECO. These include items such as low flow toilets, showerheads and faucet aerators (generally offered at low cost or no cost by EBMUD); hot and cold water piping insulation at least 5 feet from the water heater; exterior door weather-stripping; fireplace closures; and simple furnace duct repair if tested duct sealing is not performed as part of a compliance option.

Compliance Options

The homeowner would choose any one of the following four retrofit options:

Prescriptive Approach

1. Air sealing + R-30 roof/ceiling insulation (if < R-13 existing roof/ceiling insulation)
2. Air sealing + duct sealing (if existing forced air heating system)
3. Air sealing + R-19 raised floor insulation (if no existing raised floor insulation)

.. or ..

Performance Approach

4. HERS 2 audit and rating on the existing house (costing approximately $700 to $900), and any combination of retrofit measures which improve the HERS score by at least 10% or achieves a rating of $\leq$ 120.

Cost Cap

If the RECO is triggered by a permit request for a remodel with a valuation greater than $50,000 (see below), there would be no cost cap on compliance which represents a modest percentage increase in overall construction cost.

If the RECO is triggered by Point-of-Sale (if Point-of-Sale is used as a trigger), there would be a cost cap of 1.0% of the sale price of the property. If the homeowner can demonstrate that no compliance option can be achieved for less than the cost cap, any prescriptive option without air sealing is acceptable.

If the RECO requirements must be met by all dwellings or older dwellings by a certain future date (see the Date Certain trigger), there is a cost cap of 1.0% of the assessed valuation of the property. If the homeowner can demonstrate that no compliance option can be achieved for less than the cost cap, any prescriptive option without air sealing is acceptable

Impact of Triggers on Greenhouse Gas Reductions

The decision on the conditions or criteria which trigger the RECO requirements has the major impact on the amount of citywide greenhouse gas reductions reached. Table 2 shows how, in the ten years following a hypothetical July 1, 2011 RECO effective date, possible RECO triggers would result in the total amount of GHG reductions compared with the Hayward Climate Action Plan (CAP) 2050 RECO goal for single family and duplex units.

Table 2. Single Family Greenhouse Gas Reductions from Different RECO Triggers

Goal or Trigger(s)	Gross % by 2021	Eligibility X Compliance Rate (%)	Total Metric Tons/Year [(1)]	% of 2050 CAP Goal by 2021
2020 CAP Goal	n/a	n/a	639	1.6%
Remodels Only	2.1%	2.1%	240	0.6%
Point-of-Sale Only	34.3%	30.9%	3,600	9.2%
Remodels + Point-of-Sale	35.7%	32.1%	3,740	9.5%
All Dwellings by Date Certain (by 2021)	100.0%	81.0%	9,437	24.0%
Pre-1978 Dwellings by Date Certain (by 2021)	72.0%	58.3%	6,792	17.3%
Remodels + Older Dwellings Date Certain	73.4%	59.4%	6,921	17.6%
2050 CAP Goal	n/a	n/a	39,304	100.0%

Note 1: Assumes average CO2e reduction per dwelling unit = 882.34 lbs./year based on the retrofit combinations shown in Section 5, Table 4.

What seems clear is that the 2050 CAP goal is very ambitious for single family RECO, a total of 39,304 metric tons/year of CO2e reduction. To move along the path toward the 2050 CAP goal at a reasonable pace by 2021, more than remodels will be necessary which alone achieves only 240 metric tons/year or 0.6% of the way to the 2050 goal. An ordinance for remodels and date certain or older homes would reach 6,921 metric tons/year or 17.6% toward the 2050 goal.

1. Introduction

The February 3, 2010 meeting of Hayward's City Council Sustainability Committee included a brief presentation and initial discussion on a possible Residential Energy Conservation Ordinance (RECO). The June 2, 2010 meeting gave direction to City Staff and Consultants to continue targeted research into a potential RECO) and to deliver findings of the research to the Sustainability Committee in advance of its September 1, 2010 meeting.

A RECO requires energy efficiency upgrades to existing homes. While many jurisdictions have adopted green building ordinances, these requirements only apply to new buildings. A RECO addresses energy use by the existing building stock and therefore has a much greater potential for overall energy savings and greenhouse gas reductions.

This report presents the major research data and analysis completed by Gabel Associates since the June 2nd Committee meeting. It summarizes research done with respect to the following RECO development topics for single family and duplex dwelling units:

- Costs of typical residential retrofit energy measures
- Energy savings, energy cost savings and reduction in greenhouse gas (GHG) emissions from a variety of retrofit measures
- Average reductions in GHG emissions per home from different energy measures
- Cost-effectiveness of retrofit measures
- Citywide GHG reductions from different RECO triggers

The work in this research effort was performed in June, July and early August, 2010 to provide the best information that could be assembled for the Sustainability Committee to consider before their next scheduled meeting. The methodology was developed to utilize available existing home energy performance and energy use data combined with an energy model calibrated to typical Hayward residential building conditions.

Multi-family buildings are not included in this initial research for a few reasons. In the interest of time and the primary focus of this RECO, single family homes in Hayward are the most important category of residential dwellings. Previous utility studies, such as the 2004 RASS study referred to and discussed in Appendix A of this report, show annual space heating in the typical multi-family unit to be around half of that in a single family house. Since 60% of dwelling units in Hayward are single family, single family and duplex units represent approximately 75% of space heating in all residential buildings in Hayward. In the East Bay, reducing space heating is one key to residential energy savings, cost-effective savings and a large impact on carbon dioxide equivalent or CO2e reductions.

To account for the differences in the warming effect of various greenhouse gases, emissions of various gases are expressed in terms of CO2 equivalent or "CO2e". This represents the amount of CO2 that would have the same relative warming effect as the combination of greenhouse gases (GHG) actually emitted.

Because multi-family housing is likely to be included in a RECO, and RECO goals are in the Hayward Climate Action Plan, multi-family RECO measures will be evaluated in a future phase of research.

2. Energy Efficiency Measures

The home energy retrofit measures evaluated in this report are those selected as appropriate in the Hayward climate zone from a list by the California Home Energy Retrofit Coordinating Committee (CA HERCC). CA HERCC is an ad hoc group of over 90 energy efficiency and program development/implementation experts from many agencies and groups including the U.S. EPA, the California Energy Commission, the California Public Utilities Commission, the California Air Resources Board, Pacific Gas and Electric Company, Sacramento Municipal Utility District, the California Building Performance Contractor's Association, county and local governments, and non-governmental organizations.

As part of its effort to coordinate, support and advance home energy efficiency retrofitting of existing homes in California, CA HERCC completed a draft *Recommended Technical Specifications for Proposed Eligible Measures* designed to clarify specific eligibility requirements for a variety of retrofit incentive programs. The measures listed are:

- Air Sealing
- Attic Insulation
- Duct Sealing (Existing)
- New Sealed Duct System
- Combustion Appliance Safety
- Wall Insulation
- Raised Floor Insulation (above Crawlspace)
- New Heating System
- New Cooling System
- New Water Heater
- Variable Speed Fan Motor
- Refrigerant Charge and Airflow
- Cool Roofs

Hayward is mild climate that is cool in winter and mild in the summer, and has very little air conditioning. As a result, several items are eliminated from the above list: new cooling system, variable speed fan motor, refrigerant charge and airflow and cool roofs. Combustion appliance safety is functionally combined with air sealing as part of a single energy measure, and a new duct system is not considered because of a high first additional cost relative to the incremental improvement over sealing an existing duct system. This leaves the following measures that were analyzed:

- *Air Sealing*
- *Attic Insulation*
- *Duct Sealing (Existing)*
- *Wall Insulation*
- *Raised Floor Insulation (above Crawlspace)*
- *New Heating System*
- *New Water Heater*

Air Sealing

Studies done over the past several decades confirm that the thermal envelope of typical existing homes leak considerably as a result of many air gaps in their construction. This leakage is associated with gaps in the roof or attic air barrier, sill plates at exterior walls, door and window frames, mail chutes, electrical and gas service penetrations, cable TV and phone lines, outdoor water faucets, dryer and other vents, exhaust fans, and room air conditioners.

A qualified professional contractor (e.g., Home Energy Rater or certified home performance contractor) can use diagnostic tools such as a blower door test to accurately measure an existing home's air leakage. By means of visual inspection, smoke testing, infrared camera and blower door, air leaks can be identified and sealed with caulking and other means to significantly reduce overall building leakage with a high level of quality assurance. Air leakage reductions in the range of 40% to 60% are not uncommon. This process is more comprehensive and more thorough in its reliance on tested quality assurance than what was referred to as "weatherization" in earlier years.

After air sealing, a qualified practitioner also checks to make sure that combustion appliances (e.g., gas furnace or wall heater, water heater, gas dryer) are venting properly to ensure a safe level of Indoor Air Quality. The contractor may also install a carbon monoxide (CO) alarm. Air sealing improves fire and combustion safety, improves moisture control and increases occupant comfort by reducing drafts and increasing the radiant temperatures of some the interior surfaces.

Air sealing is listed first as the essential retrofit measure in all major home retrofit incentive programs, and is required before any insulation is added to the house. It is first in "loading order" because most other energy measures don't make sense to install until significant leaks have been plugged; and because it includes other important health safety and other benefits beyond energy efficiency.

In interviews with staff from Gabel Associates, several home performance contractors cited an air change rate per hour (ACH) of around 1.0 as typical for existing homes in the Bay Area prior to retrofit air sealing work. This means that in one hour 100 percent of the air in a home is replaced with air from outside the home. These home performance contractors reported that the air change rate is commonly reduced to a post-retrofit value of 0.5 ACH as a result of reasonably feasible and careful air sealing.

The above pre-retrofit air leakage rate value is consistent with the so-called "normalized leakage" per home reported at 1.03 ACH to 1.24 ACH in a Lawrence Berkeley National Laboratory paper titled "*Air Leakage of U.S. Homes: Model Prediction*" published 2007 by Sherman and McWilliams (LBNL-62078).

Schematic of Home Envelope and Sources of Common Air Leakage

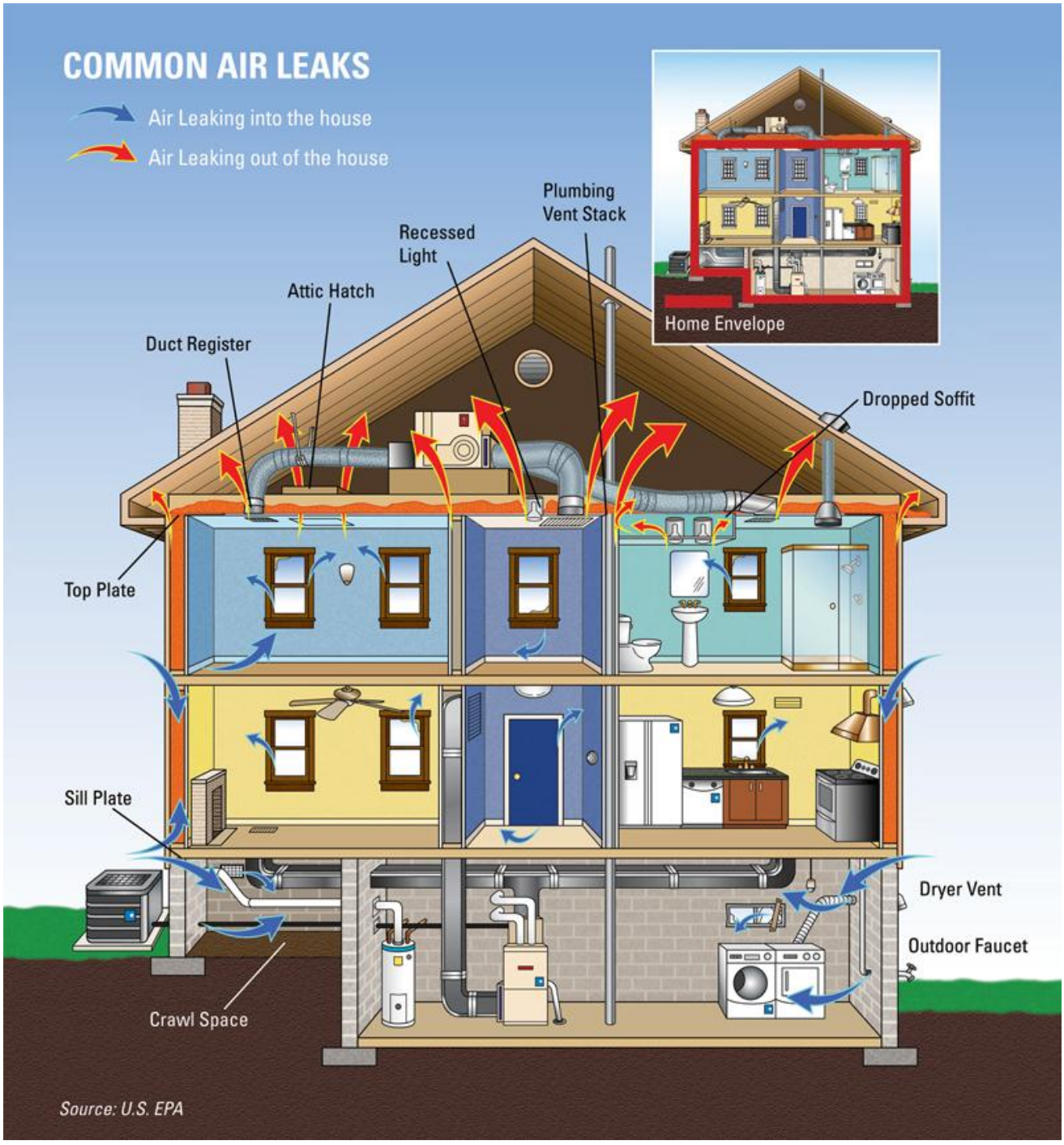


Photo courtesy of U.S. EPA Energy Star

Blower Door Test Equipment

Photo courtesy of resourcefulenergy.net

Attic Insulation

After air sealing has been completed attic insulation should be evaluated. New insulation in a previously un-insulated attic should be installed in accordance with the "Quality Insulation Installation" (QII) criteria specified in the Title 24 energy standards by a qualified contractor. If there is already some existing attic insulation in place, the main issue is to decide whether to upgrade it. That will depend on assessing both the quality of the previous installation as well as the thickness of the existing insulation. Installation flaws that can seriously degrade the thermal performance of the insulation include:

- Insulation not in contact with the air barrier;
- Gaps or voids in the insulation that leave some areas not insulated;
- Compression of the insulation reducing the thickness and rated R-value.

It is not uncommon for poorly installed insulation batts to have their overall rated R-value effectively reduced by 20% or 40% or more because of these problems. For example, existing "R-13" labeled insulation batts may be providing an effective thermal resistance of only R-9 or less based on a multitude of flaws with the original installation.

The current Title 24 energy standards require that an upgrade to attic insulation in Hayward (Climate Zone 3) must achieve a minimum of R-30 which is equivalent to a 9.5 inch thickness of blown-in or batt insulation. Major home energy retrofit incentive programs generally require that attic insulation be upgraded to R-38 (e.g.,12 inches thick) to be eligible for energy rebates. Section 4 of this report discusses the differences in cost-effectiveness based on the pre- and post-retrofit attic insulation levels in the mild San Francisco Bay Area climate.

Poor Installation of Roof Insulation: Compression and Gaps

Photo courtesy of Rick Chitwood

Sealing Existing Duct Systems

The extent to which duct systems in existing homes contribute to heating and cooling energy use has been a subject of much study since the late 1980s. Research work done in the 1990s "*showed that air duct losses on the order of 35% were typical in residential construction (Jump, et at, 1994)*" as summarized in a 2001 paper by John A. Bryant. Interviews of Bay Area home performance contractors by Gabel Associates indicate that tested duct leakage in existing homes is typically in the range of 30% to 35% or higher. One home performance contractor who tested the duct leakage in 200 existing homes in the past few years reports that the average duct leakage value was 37.5%.

Qualified technicians use duct testing equipment to (a) measure the overall leakage of an existing or new duct system; (b) find leaks in the system; (c) employ several different methods to seal duct leakage and (d) re-test the system to achieve the specified level of performance. In existing California homes, the goal of sealing existing ducts is established in the state's *Reference Appendices for the 2008 Building Energy Efficiency Standards*, Table RA3.1-2. This table sets leakage criteria as a percentage (%) of total fan flow for sealed and tested altered existing duct systems at 15%, a value that Bay Area home performance contractors indicate they achieve in a very high percentage of homes.

Duct Testing Equipment

Photo courtesy of directindustry.com

Wall Insulation

Prior to the 1970s, which included the 1973 Oil Embargo and the initial 1978 Title 24 building energy standards, most existing homes in the Bay Area were built with no wall insulation. While insulating walls is a potentially important option in reducing home energy use, there can be a significant cost with this upgrade if interior sheetrock or plaster or other interior siding has not already been removed as part of a major alteration.

When interior and exterior wall sidings are not removed, insulation is blown into the cavities by drilling holes between the wood studs, injecting the insulation, patching the holes, and applying or repairing the finish. If holes are drilled through interior dry wall, holes can be filled and smoothed, but the surface must be repainted. Holes cannot be drilled through plaster, as plaster will crack; or through any material that cannot be easily repaired (e.g. tile or unpainted wood). Insulation can also be blown in through holes in exterior sheathing, but the process involves similar limitations with respect to exterior siding and finishes.

For the purpose of this study, the cost of upgrading wall insulation is assumed to be blown-in through inside dry wall of exterior walls, with all steps taken to repair and prepare the dry wall without repainting. The idea is that a homeowner having already decided to repaint the interior of the house might choose to add the extra cost to insulate the walls.

Retrofit Blown-in Wall Insulation

Photo courtesy of northerninsulation.biz

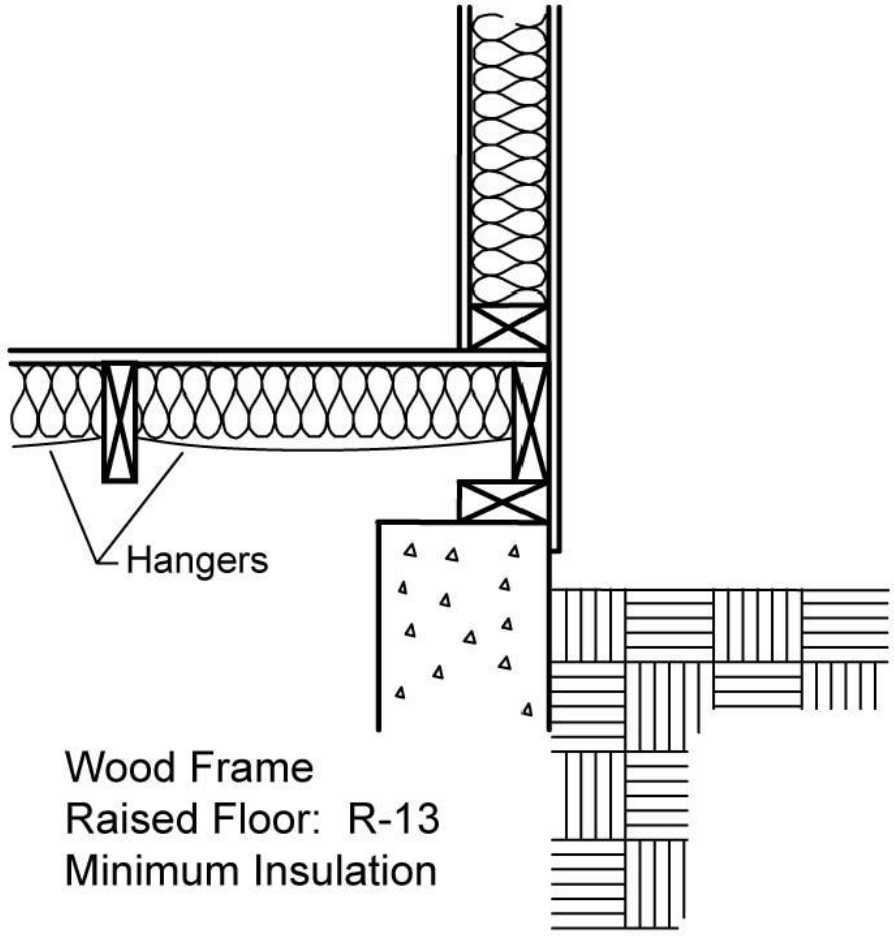
Raised Floor Insulation

Most existing homes built prior to the 1970s as discussed above also have no insulation in the raised floor over unconditioned areas such as crawl spaces, garages and unheated basements. If above an accessible crawl space, insulation is typically installed between floor joists. Quality installation means ensuring that insulation batts are in full contact with the air barrier (e.g., subfloor); and that mechanically fastened netting or fabric ensures the insulation does not sag or droop or is compressed. In some instances, a vapor barrier on the floor of the crawl space may be required to reduce moisture.

If raised floor joists are open below to an existing garage or basement space or to an outdoor area, installation of insulation may be relatively easy.

The cost data for upgrading floor insulation in this study is based on an accessible crawl space with a minimum height of 18 inches.

Raised Floor Insulation



From the 2008 Residential Compliance Manual

New Space Heating

While replacing an older, inefficient forced air furnace may significantly reduce energy use, space heating equipment as a retrofit measure is not included in this evaluation of potential RECO retrofit measures. This exclusion is based on two significant issues:

(1) A condensing furnace upgrade alone – without altering the existing duct system – is normally in the range of $3,000 to $5,000 according to a reputable local mechanical heating contractor; and,

(2) Federal appliance (NAECA) standards do not allow local jurisdictions to establish a prescriptive requirement for furnace efficiency that exceeds the national minimum of 78% AFUE.

New Water Heating

Because replacing a standard gas tank water heater is normally in the range of $1,200 to $1,800 (as reported in Section 3), first cost is not an insurmountable barrier in considering it for a RECO ordinance. While water heater efficiency is regulated by NAECA, an energy performance approach can essentially circumvent the federal appliance standards restriction if a local code does not explicitly prescribe installing a high-efficiency water heater. A new gas water heater was included in the study as a performance option.

Appliances and Permanently Installed Lighting

The California Home Energy Rating System for existing homes (HERS 2) includes both audit and analysis of an inventory of major appliances including refrigerator, stove/range, dishwasher and washing machine; as well as the presence of a swimming pool, spa, well pump or sewer grinder pump. A listing of fixed (permanently installed) indoor and outdoor lighting is also included. However, while these items have an impact on overall home energy use and CO2-e emissions, they are excluded from this particular study for several reasons:

(1) Given the limited time available within which to conduct this study, the main focus has been on reducing space heating and water heating energy use which together comprise almost 70% of the energy use and CO2 emissions of a small existing Hayward home.

(2) Improving the efficiency of major appliances and fixed lighting which total around 25% of the home energy use is based on a series of many incremental steps for which average cost data is more difficult to obtain.

(3) Possible prescriptive measures do not include appliances, and probably will not include lighting. A separate analysis of upgrading fixed lighting efficiency may be done in future work.

(4) Previous work by Gabel Associates for the City of Berkeley studying the HERS 2 rating index indicates that improvements to appliance and lighting efficiency do not significantly improve the overall HERS 2 score as compared with measures that reduce space heating and water heating.

For further description and discussion of the HERS 2 rating system, see Section 3.

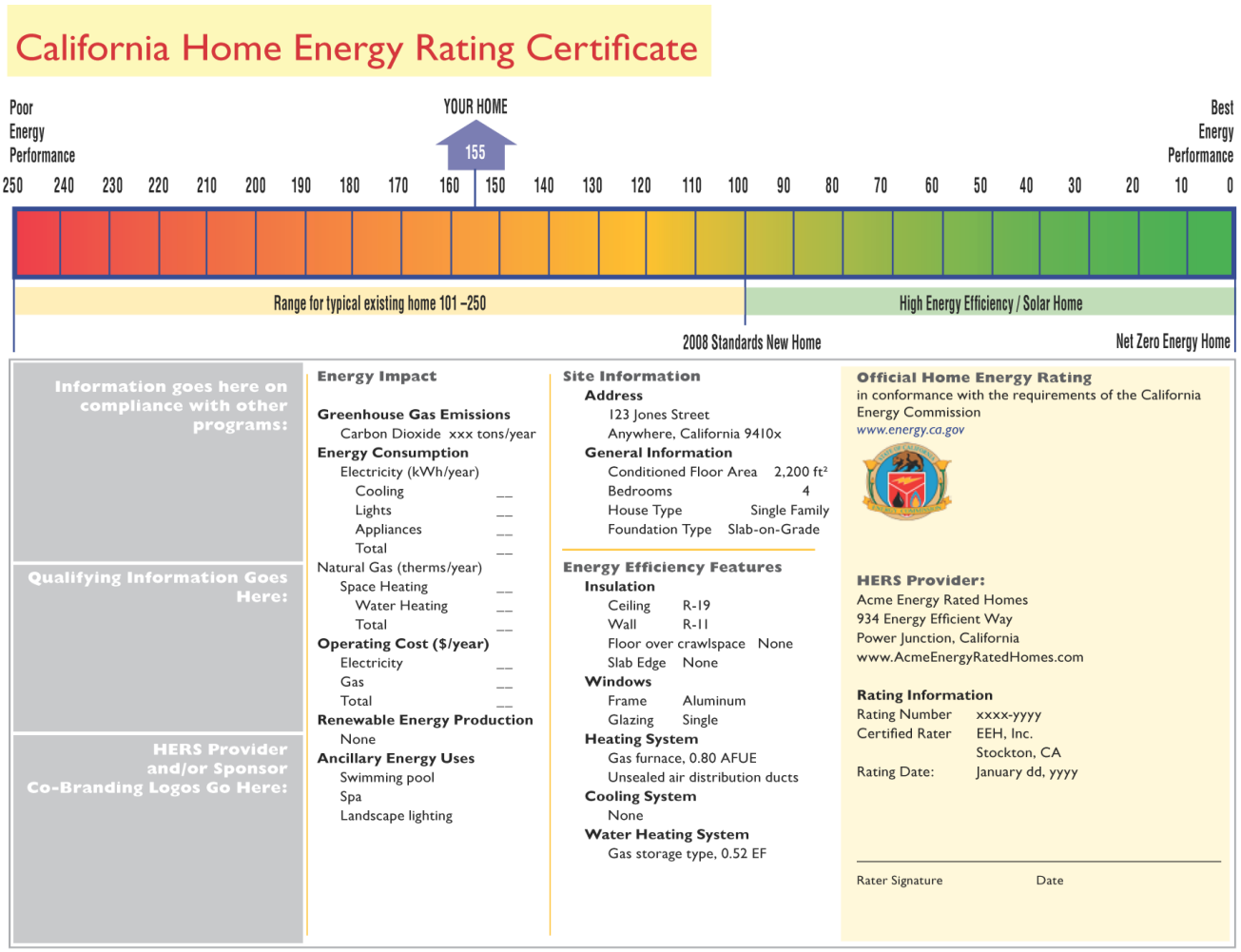
3. HERS Description and Incentives

HERS 2 Software

The California Home Energy Rating System for Existing Homes – known as "HERS Phase II" or "HERS 2" -- is a residential building energy audit and rating system that has been established by California Public Resources Code 25942. The main goals of a HERS 2 Rating as described by the California Energy Commission (CEC) are "*a consistent, accurate and uniform rating based on a single statewide rating scale; and estimates of potential utility bill saving and recommendations on cost-effective measures to improve energy efficiency.*"

The HERS rating includes (a) a detailed home energy audit including a field inspection and different tests performed by a certified HERS Rater; (b) an energy analysis of the existing conditions to determine the HERS score; and (c) a standardized report which identifies which retrofit measures are most cost-effective based on specific existing house conditions, the cost of measures and projected annual energy cost savings.

HERS 2 Rating Label for Existing Homes



The HERS rating certificate (shown above) indicates how the projected annual energy use of an existing home compares to the same home which just meets the 2008 Title 24 Building Energy Efficiency Standards. The 2008 Title 24 home is defined as having a score of 100, while a Net Zero Energy home has a HERS score of zero. Existing homes often have scores above 100 (e.g., 150 to 200). The HERS rating has been developed to be independent of the behavior of residents, and is based solely on the physical characteristics of the existing house including roof, walls, floor, windows, overall building leakage, mechanical system and ducts, water heater, lighting and major appliances.

Recently released HERS 2 software was approved on July 28, 2010 by the California Energy Commission. The main energy calculation within the HERS 2 software is a residential hourly computer simulation or energy model (e.g, Micropas or Calres) that has been used and revised by the CEC since it was first used for Title 24 compliance of new buildings in 1983. Aside from calculating annual time dependent valuation (TDV) energy use -- the basis of the 2008 Title 24 standards and the HERS 2 rating -- it also calculates annual building site energy use of natural gas and electricity. As the EPA Highway Mileage tests the relative performance of a car's gasoline mileage independent of an individual's personal driving style or particular traffic conditions, the computer simulation within the HERS 2 software provides a good relative indicator of the impacts of specific energy design improvements to an existing or base case building design.

The HERS 2 computer simulation models the heat transfer in and out of the house through every surface – roofs, walls, floor, windows – as well as through natural infiltration, and including the typical internal gain from people, lights, appliances, TVs, computers and other items plugged into electric outlets. The program does this calculation for all the hours in the year – 8,760 hours – based on local hourly weather data, the position of the sun, how much solar gain enters the house through the area and orientation of windows, and so on; and based on the specified daytime and nighttime thermostat settings.

Most useful and interesting about computer simulations is that <u>they keep everything about the building energy design and the weather constant except for the energy features that change from one run to the next</u>. As a result, it is possible to isolate the effects of particular energy efficiency measures or combinations of measures. The value of parametric studies is to get a better understanding of the relative performance of different energy measures. This type of energy software – in the hands of experienced users with attention paid to operating assumptions, occupant assumptions, accurate inputs of building design features, and knowledge of how the program is modeling specific features -- has a good track record in ranking the energy impacts of different energy design choices.

One of the great challenges in interpreting the results of energy software is ensuring that total predicted energy use is reasonably similar to what a typical real-world building with the exact same modeled design specification will actually use. In this study, we have had the cooperation and assistance from PG&E which provided average utility data for the approximately 29,000 single family units and single family attached (duplex) units in Hayward. Because the Base Case model is calibrated to real energy use data in this study, the HERS 2 energy software is helpful in predicting relatively accurate energy use effects of different retrofit measures. This is the basis of the approach used to estimate energy performance and cost-effectiveness.

Residential Energy Retrofit Incentives

There are a variety of home energy retrofit incentives and tax credits currently available, soon-to-be available or possibly to be implemented within the next year. Prescriptive incentives are based on verifying the installation of one or more identified measures by a qualified contractor. Performance incentives are based on installing one or more measures resulting in a certain amount of energy savings as calculated by the HERS 2 software. A summary of these incentives is expected this fall under the statewide program name "Energy Upgrade California" which will have a web site providing details and eligibility rules for these rebates and financing opportunities.

PG&E Incentives

Current prescriptive incentives include specific amounts for individual retrofit measures such as $150 for insulating at least 1,000 square feet of attic space to R-30; and $100 for sealing and testing of existing duct systems. Added to that is a $1,000 incentive beginning in the fall, 2010 through March, 2012 for the combination of air sealing, R-38 attic insulation and duct sealing.

Performance-based utility incentives will be based on the following eligibility criteria:

- $2,000 or half the project cost, whichever is less, for upgrades which reduce the HERS rating score by at least 20%;
- Each additional 5% reduction earns another $375 up to a total of $3,500 or half the project cost.

Federal Tax Credits (Pending)

U.S. Home Star Silver prescriptive incentives are part of the energy bill pending in Congress which may be approved and funded by the end of the year. Home Star Silver would provide rebates to homeowners of up to $3,000 for specific energy upgrades, and up to 50% of the project cost (whichever is less).

U.S. Home Star Gold performance incentives would provide rebates up to $3,000 for upgrades which reduce the HERS rating score by at least 20%; and up to $8,000 when additional savings are achieved.

PACE Financing

PACE (Property Assessed Clean Energy) programs were established to enable local governments to finance renewable energy and energy efficiency projects on private property, including residential, commercial and industrial properties. The chief advantage for the building owner is very low or no upfront cost. Most PACE financing has been on hold since a July 6, 2010 statement by the Federal Housing Finance Agency (FHFA) indicating that senior PACE liens are in violation of their standard mortgage contracts. Shile a national legislative strategy is in place to mitigate the position of the FHFA, the ultimate fate of PACE financing is in doubt. In California, PACE funding has been designed to fund residential energy efficiency projects which reduce the HERS rating score by at least 10%.

4. Cost of Measures, Energy Savings and Cost-Effectiveness

To establish the current costs of standard retrofit measures for a typical Hayward home, two sets of cost data were gathered from a total of seven certified home performance contractors. Table 1 in the Executive Summary (and distilled from the full data in Tables 3a and 3b presented in this section) shows a number of measures according to their average cost. Section 2 contains a discussion of the retrofit measures. Descriptions of terminology in these tables are included at the end of this section.

An important aspect of the research into the cost-effectiveness of energy retrofit measures is to obtain current, real-world installation costs. The general approach used in obtaining this information was to use two sources of data:

- **Cost Data Set A.** Data from two Bay Area home performance contractors operating in the East Bay who completed a detailed spreadsheet developed specifically for this study by Gabel Associates; and,

- **Cost Data Set B.** Data obtained via a utility company whose consultant compiled similar current information from five home performance contractors operating in the Bay Area and in other parts of Northern California.

The data is presented in Appendix A, Detailed Cost Data. A summary of the average cost for each retrofit measure is included in Table 1b in the Section 5.

Tables 5a and 5b summarize the results of study in illustrating several important impacts of installing various home energy retrofit measures, followed by a description of key terms.

Table 3a. Retrofit Energy Savings and HERS Ratings

ERM #	Description of Measures	Existing Home + Energy Retrofit Measures (ERMs)				
		Total Space & Water Heating (Therms/Yr)	Adjusted HERS Rating	Annual Gas Saving (Therms/Yr)	Improvement in HERS Rating (%)	Annual CO2e Reduction (Lbs./Yr)
	BC: Base Case Home with No Attic Insulation	***499***	***194***	***NA***	***NA***	***NA***
1	BC + Air Sealing	**461**	**184**	**38**	**5%**	**445**
2	BC + R-30 Attic	**455**	**172**	**43**	**11%**	**511**
3	BC + R-38 Attic	**454**	**171**	**44**	**12%**	**522**
4	BC + Air Sealing + R-30 Attic	**418**	**161**	**81**	**17%**	**951**
5	BC + Air Sealing + R-38 Attic	**416**	**160**	**82**	**18%**	**967**
6	BC + Duct Sealing	**465**	**182**	**34**	**6%**	**396**
7	BC + Air Sealing + Duct Sealing	**427**	**173**	**71**	**11%**	**841**
8	BC + Air Sealing + R-30 Attic + Duct Sealing	**393**	**152**	**105**	**22%**	**1,242**
9	BC + Air Sealing + R-38 Attic + Duct Sealing	**392**	**151**	**107**	**22%**	**1,258**
10	BC + DHW EF=0.58	**477**	**190**	**22**	**2%**	**257**
11	BC + DHW EF=0.62	**463**	**188**	**35**	**3%**	**415**
12	BC + Air Sealing + R-13 Walls	**385**	**158**	**113**	**19%**	**1,335**
13	BC + Air Sealing + R-19 Floor	**423**	**173**	**76**	**11%**	**890**
14	ERM 8 + R-13 Walls	**314**	**125**	**184**	**36%**	**2,171**
15	ERM 8 + R-19 Floor	**355**	**136**	**143**	**30%**	**1,687**
16	ERM 8 + R-13 Walls + R-19 Floor	**290**	**120**	**209**	**38%**	**2,462**

Table 3a can be used to understand the natural gas savings and HERS rating adjustment due to the installation of a specific energy retrofit measures (ERM) or combination of ERMs. For example, compared to the base case (BC), Air Sealing (ERM 1), reduces annual natural gas use by 38 therms and improves the HERS rating by 5%.

The improvement in the Adjusted HERS Rating (%) is a significant metric because it's used as the basis for performance incentives as explained in the previous section.

The "Average Payback with No Incentives" represents the simple payback of the measures (Cost / Annual Energy Cost Saving) with no incentives or rebates from the utility company, or any tax credits from the federal government. To illustrate the potential impacts of incentives, the last two columns include the combined impacts of prescriptive home energy retrofit rebates from PG&E and expected U.S. Home Star Silver prescriptive tax credits not yet funded by Congress.

Of particular note are several ERMs which (a) have an installed cost at or below $3,000; (b) have a simple payback without any incentives of around 30 to 35 years; and (c) improve the HERS rating score by more than 10%. The ERMs which meet all three criteria are:

- ERM 4: **Air Sealing + R-30 Attic Insulation (from an R-0 attic)**
- ERM 5: **Air Sealing + R-38 Attic Insulation (from an R-0 attic)**
- ERM 7: **Air Sealing + Duct Sealing**
- ERM 13: **Air Sealing + R-19 Floor (from an R-0 raised floor over a crawl space)**

Utility company performance-based retrofit incentives and the U.S. Home Star Gold incentives both require that homes be improved by at least 20% using the HERS 2 rating score to be eligible for those programs. ERMs which meet the 20% threshold include:

- ERM 8: **Air Sealing + Duct Sealing + R-30 Attic Insulation (from an R-0 attic)**
- ERM 9: **Air Sealing + Duct Sealing + R-38 Attic Insulation (from an R-0 attic)**
- ERM 15: **ERM 8 + R-19 Floor (from an R-0 raised floor over a crawl space)**
- ERM 16: **ERM 8 + R-13 Walls (from R-0) + R-19 Floor)**

Table 3b. Retrofit Costs and Paybacks

		Existing Home + Energy Retrofit Measures (ERMs)				
ERM #	Description of Measures	Improvement in HERS Rating (%)	Average Retrofit Cost ($)	Average Payback with No Incentives (Years)	Net Retrofit Cost with Incentives ($)	Average Payback with Incentives (Years) [1]
	BC: Base Case Home with No Attic Insulation	**NA**	**NA**	**NA**	**NA**	**NA**
1	BC + Air Sealing	**5%**	**$1,411**	**33.9**	**$706**	**16.9**
2	BC + R-30 Attic	**11%**	**$1,178**	**24.6**	**$1,028**	**21.5**
3	BC + R-38 Attic	**12%**	**$1,319**	**27.0**	**$1,169**	**23.9**
4	BC + Air Sealing + R-30 Attic	**17%**	**$2,589**	**29.1**	**$1,589**	**17.8**
5	BC + Air Sealing + R-38 Attic	**18%**	**$2,828**	**31.2**	**$1,414**	**15.6**
6	BC + Duct Sealing	**6%**	**$1,029**	**27.8**	**$415**	**11.2**
7	BC + Air Sealing + Duct Sealing	**11%**	**$2,440**	**31.0**	**$1,220**	**15.5**
8	BC + Air Sealing + R-30 Attic + Duct Sealing	**22%**	**$3,617**	**31.1**	**$1,809**	**15.6**
9	BC + Air Sealing + R-38 Attic + Duct Sealing	**22%**	**$3,856**	**32.7**	**$928**	**7.9**
10	BC + DHW EF=0.58	**2%**	**$1,400**	**58.1**	**$1,400**	**58.1**
11	BC + DHW EF=0.62	**3%**	**$1,625**	**41.8**	**$1,625**	**41.8**
12	BC + Air Sealing + R-13 Walls	**19%**	**$4,275**	**34.2**	**$2,275**	**18.2**
13	BC + Air Sealing + R-19 Floor	**11%**	**$3,016**	**36.2**	**$1,508**	**18.1**
14	ERM 8 + R-13 Walls	**36%**	**$6,481**	**31.9**	**$2,481**	**12.2**
15	ERM 8 + R-19 Floor	**30%**	**$5,222**	**33.1**	**$1,611**	**10.2**
16	ERM 8 + R-13 Walls + R-19 Floor	**38%**	**$8,086**	**35.1**	**$4,086**	**17.7**

Note 1: Includes combined Prescriptive incentives from PG&E and U.S. Home Star Silver program

BC. For the purposes of this study and in the previous tables, the Base Case is the pre-retrofit home that is 1,292 square feet and has no attic insulation detailed in Appendix A

ERM#. The Energy Retrofit Measure number that represents one retrofit scenario in which one or more energy efficiency measures are installed as compared with the Base Case Home with No Attic Insulation (ERM-0).

Description of Measures. The existing Base Case (BC) plus one or more retrofit items added to test their impact. ERMs #15 through #18 include all ERM-8 features and add to that other items listed.

Total Space + Water Heating (Therms/Year). The total annual natural gas use for space heating and water heating combined as calculated by the HERS 2 energy software; and normalized according to average Hayward home utility data (explained in Section 4.)

HERS Rating (Adjusted). The HERS 2 rating generated by the HERS 2 software for the specific energy retrofit measure(s) listed; and, in some instances, adjusted to account more accurately for some aspect of the installed features than the software is currently capable of modeling (see findings in Section 7.) The lower the HERS rating number, the more energy efficient the building.

Annual Gas Savings (Therms/Year). The annual natural gas savings as a result of the installation of the ERM as compared with the Base Case home with no attic insulation.

Reduction in HERS Rating (%). The percentage reduction in the adjusted HERS Rating score for the listed ERM as compared with the Base Case Home with No Attic Insulation.

Annual CO2e Reduction (Lbs.). The annual reduction in CO2-equivalent greenhouse gases according the conversion factors used in the Hayward Climate Action Plan: 11.79 Lb. CO2e/Therm and 0.49 Lb. CO2e/KWh. This value is discussed further in Section 5.

Average Retrofit Cost ($). The average cost obtained for ERMs as explained in Section 3.

Average Simple Payback (Without Incentives) . This is the payback of installing the retrofit measure, expressed in years, without accounting for any incentives or rebates. The formula used to calculation this value = (Average Retrofit Cost in $) / (Annual Gas Saving in therms/year) x (unit cost of gas in $/therm). The unit cost used is $1.104/therm which is the average unit cost paid by Hayward homeowners from 2007 through 2009.

Average Payback (With Incentives). The Simple Payback (without any incentives) is adjusted to include the net reduced installation cost to the homeowner of each ERM taking into account current or expected PG&E prescriptive incentives and the U.S. Home Star Silver prescriptive incentives. The U.S. Home Star program legislation has not yet passed or been funded by the Congress.

5. Greenhouse Gas Reductions

In addition to the results of the study summarized in Section 4, CO2-e reductions for each energy retrofit measures have been calculated. From this information, and from data from City staff on the demographics of key energy-related features of single family and duplex dwelling units in Hayward, it is possible to establish the larger impacts of a Hayward RECO with respect to citywide CO2-e greenhouse gas reductions and the goals contained in the October 8, 2009 *Hayward Climate Action Plan (CAP)*.

The CAP calls for reducing 639 metric tons per year of CO2-e in single family homes by 2020 and reducing 39,304 tons/yr by 2050. It also calls for reducing CO2-e in multi-family units 993 tons/yr by 2020 and 33,033 tons/yr by 2050.

The CO2e reduction calculations shown in Table 4 have been done assuming all single family and duplex units meet the proposed RECO requirements. These results are adjusted in Table 5 to reflect the total percentage (%) of single family units affected by a RECO over a 10 year period based on different trigger requirements such as Remodels, Point-of-Sale and Date Certain discussed further in the next section.

Table 4. Summary of GHG Impacts on Single Family Units

ERM #	Description of Measures	Total Dwelling Units	Annual CO2e Reduction (Lbs./Unit)	Annual CO2e Reduction (Metric Tons)
4	Air Sealing + R-30 Attic (QII): from R-0 attic	8,189	951	3,531
7	Air Sealing + Duct Sealing	14,205	841	5,417
13	Air Sealing + R-19 Floor (accessible crawl spaces)	3,810	890	1,538
	Exempt: 10%	2,912	0	0
	Totals:	29,116		10,486

Table 4 assumes that all single family and duplex units are upgraded under a RECO ordinance that exempts 10% of all units (e.g., extreme financial hardship, medical disabilities of the owners) while requiring the following of eligible units:

- *Homes with un-insulated attics are retrofitted with air sealing + R-30 attic insulation.* This is estimated as 34% (from RASS study) of the 26,761 units (from City of Hayward data) listed as having attic spaces = 9,099 units. When reduced by 10% exemptions this value = 8,189 units.

- *Homes with some existing attic insulation or with no attics would be required or encouraged to retrofit with air sealing + duct sealing if there is a forced air system.* This would be all the remaining units with forced air furnaces which, according to City data, is 83% of all homes (i.e., 17% of homes have wall heaters). So: (29,116 – 9,099) x 0.83 = 20,017 x 0.83 = 16,614 units in this category. When reduced by 10% exemptions this value = 14,205 units.

- *Homes with wall heaters and no attic or existing attic insulation would be required to retrofit with air sealing + R-19 raised floor over an accessible crawl space.* The

remaining total dwelling units not included above = 4,234 units in this category. When reduced by 10% exemptions this value = 3,810 units.

Under a Date Certain RECO in which all single family and duplex units meet RECO requirements by the end of 2020, and assuming a 100% compliance rate, the overall citywide reduction in CO2e is projected to be 10,486 metric tons. Table 5 shows the 10 year performance of a RECO with the above required retrofit measures assuming that there is a 100% compliance/enforcement rate only for the remodels trigger, and a 90% compliance/enforcement rate for Point of Sale and Date Certain.

- Remodels are projected to reach 2.1% of single family units;
- Point-of-Sale is projected to reach 34.3% x 0.90 = 30.9% of single family units;
- Date certain is projected to reach 90% x 0.90 = 81% of single family units.

Table 5. Hayward Climate Action Plan Metrics

		Single Family/Duplex RECO Triggers			
	2020 CAP Goal	Remodels by 2021	Point-of-Sale by 2021	Date Certain by 2021	2050 CAP Goal
Eligibility x Compliance Rate	n/a	2.1%	30.9%	81.0%	n/a
Total Metric Tons/year	639	240	3,601	9,439	39,304
% of 2050 CAP Goal	1.6%	0.6%	9.2%	24.0%	100.0%

6. Findings and Recommendations

As presented in earlier meetings of the Sustainability Committee on February 3rd and June 2nd, Hayward is a relatively mild Bay Area climate with a modest amount of space heating and very little cooling. As a result, retrofit measures that may pay back more quickly in inland areas of the state have much longer paybacks in coastal areas. The results show a wide range of paybacks, generally over 25 years without incentives. The majority of the measures and measure combinations can be installed for under $5,000 and many improve the HERS rating by more than 10% for $3,000 or less.

The study shows that even in Hayward's mild climate, and without incentives, the installation of air sealing results in relatively acceptable cost effectiveness. In particular, several retrofit combinations look promising:

- Air Sealing + R-30 Attic (if the existing attic is un-insulated)
- Air Sealing + Duct Sealing (if there is an existing forced air system with ducts)
- Air Sealing + R-19 Floor (over an accessible crawlspace or other unconditioned area)

Other benefits of these retrofit combinations include:

- Each averages between $2,500 and $3,000 in installed cost without incentives
- Average annual CO2e reduction ranges from 841 to 951 pounds per year; and,
- The reduction in the HERS 2 rating is 11% to 17%.

Additionally, many retrofit measures add real and substantial value beyond energy and cost savings. For example, air sealing provides several additional co-benefits:

(1) Air sealing improves fire and combustion safety, and also improves indoor air quality which can include the installation of a carbon monoxide (CO) sensor;

(2) Air sealing increases the value of the home and/or improves marketability in the eyes of prospective educated buyers; and,

(3) Air sealing is a key measure that must be installed to be eligible for several utility and potential federal incentive programs.

Possible RECO Triggers

Remodels

The most common RECO trigger, remodels, requires that an application and set of construction drawings for permit be approved by the building department. This trigger is generally defined as a minimum construction cost. For example, the City of Berkeley RECO has set the remodel cost $\geq$ $50,000. Typically this would be a 200 sq.ft. or 250 sq.ft. addition to existing house, or substantial home remodels that make other improvements. In this scenario, the cost of RECO compliance is considered a reasonable incremental cost as compared with the overall permitting and construction costs.

Based on recent Hayward permit data, 600 single family and duplex units are expected to undergo a remodel in the next 10 years that would be affected by this trigger; or only 2.1% of all dwelling units. As shown in Table 5, this would reduce CO2e by 240 metric tons/year as compared with the relatively low Hayward CAP 2020 goal of 639 metric tons/yr for single family and duplex homes. Therefore, remodels alone reduce CO2e only 0.6% of the total CO2e reduction called for by the CAP by 2050 for Single Family RECO.

Point of Sale

Point of Sale is a trigger that has been in place for many years within the Berkeley and San Francisco RECOs. Either the seller fulfills RECO requirements prior to sale, or the buyer verifies RECO compliance within a certain number of months after the transfer of title (i.e., time after sale). The grace period provided to the buyer is 12 months in Berkeley and 6 months in San Francisco. The grace period could be a longer period such as 24 or 36 months if the City can track and enforce the RECO provisions after transfer of title. Depending on how the City decides the policy, an investor who purchases a home and resells it within the grace period might or might not be exempt from the RECO requirements. For example, Berkeley allows a property to be re-sold within the time-after-sale grace period without requiring RECO compliance.

The percentage (%) cap on homeowner spending to meet the requirement under the Point of Sale trigger is based on the property purchase price. Assuming an annual average of 1,000 single family and duplex units sold in Hayward, the Point of Sale trigger alone would reach 34.3% of homes by 2020. With a net compliance rate of 90%, that would reduce CO2e by 3,601 metric tons/yr and achieve 9.2% of the 2050 CAP greenhouse gas reduction goal. With some overlap, the combined Remodel and Point of Sale might succeed in reducing CO2e by 9.4% of the 2050 CAP goal (see Table 2 in the Executive Summary).

A considerable obstacle in adopting a RECO implementing the Point of Sale trigger is the strong opposition by local real estate agents who have appeared at public meetings to express their concern that this trigger unfairly targets their clients. Our research has not yet identified any statistical data that the Berkeley Point of Sale RECO has had any effect on home sales as compared with home sales in surrounding communities since the Berkeley RECO first took effect.

Date Certain

A potential RECO trigger that was discussed but not implemented in the revised Berkeley RECO is what has been termed “Date Certain”. This is the scenario in which all dwelling units covered by the RECO – or only older homes built before 1978-- must meet compliance requirements by a certain or fixed date (e.g., 10 or 12 years from the RECO effective date). As discussed briefly at the June 2nd Committee meeting, the advantage over other triggers is much greater market penetration of quality home energy retrofits if this can be successfully implemented and enforced.

Table 5 assumptions for this trigger are a total of 10% of homes exempted for as yet non-specific reasons, and a compliance/enforcement rate of 90% of eligible dwellings for a net penetration of 81% of single family dwellings. Based on this rate, 2020 reductions in CO2e are projected at 9,439 metric tons/yr, or 24.0% of the CAP 2050 greenhouse gas reduction goal. If only older homes are targeted (e.g., built prior to 1978 Title 24 energy standards), 2020 reductions in CO2e are projected at 6,792 metric tons/yr, or 17.3% of the CAP 2050 greenhouse gas reduction goal. Because 2020 is one-quarter of the way from 2010 to 2050, a Date Certain ordinance can keep the pace of CO2e reductions set by the CAP 2050 greenhouse gas reduction goal.

The main disadvantage and obstacle of a Date Certain approach is the great likelihood that the vast majority of homeowners simply wait until very close to the final deadline (e.g., 2019) to take RECO compliance seriously and have the required retrofits installed only at the last moment to avoid a fine. Additionally, there is the risk that public pressure might persuade a future City Council to delay the ordinance, reduce the requirements or rescind it entirely.

However, there are other ways of considering the Date Certain trigger that may make it an attractive option that would work well within a larger context.

(1) Knowing that their home would eventually require certain energy efficiency improvements, homeowners will be more likely to use whatever incentives are available to get the work done sooner than later along with lower utility bills and other benefits.

(2) A delay by most homeowners in complying with a Date Certain ordinance has several implementation advantages. It allows time for the City to get the basic RECO procedures in place, test them out, do education and outreach to the community, develop the web site, and generally get the RECO functioning before large numbers of homeowners are ready to file and comply.

(3) Date Certain allows the City to conduct a mid-course review of the ordinance three to five years after it takes effect to determine how well the projections of energy savings, CO2e reductions and cost-effectiveness of the required retrofits compare with monitored data. A review could lead to a mid-course correction to the ordinance concerning implementation procedures or the types of RECO measures required for compliance. An important question to consider is how to ensure that the right kind of future data can be gathered to conduct a review in, for example, 2016.

(4) Even if the Point of Sale or Time After Sale trigger is not implemented, some percentage of home sellers in Hayward will be motivated to voluntarily meet the RECO requirements to achieve a marketing advantage. And educated home buyers are likely to place a competitive value on a home which has already met RECO.

(5) Given the challenges in planning and implementing effective tracking, notification and enforcement of a RECO affecting a large fraction of single family homes, there would be several years during which City staff could work out the most efficient way to manage the administration of the ordinance preceding the final deadline.

Conclusions and Recommendations

This study establishes that there are three good and generally equivalent combinations of prescriptive RECO measures for typical single family Hayward homes that significantly reduce energy use and are cost-effective. We recommend that all three retrofit options be offered to homeowners as part of a prescriptive path within a Hayward RECO. We further recommend that the performance option be the HERS 2 audit and rating plus a demonstration that the existing HERS 2 score is improved by at least 10%.

Our discussions about the structure of these proposed RECO requirements with a home performance contractor and a HERS rater have been positive. They like the amount of flexibility offered within the prescriptive path. And there is the opportunity for a home performance contractor, after making an initial visit to a home, to consult with the homeowner about existing house conditions and which retrofit option would make the most sense without having to perform a full HERS 2 audit, rating and report.

Even though policy makers and the home performance contracting industry is understandably trying to move homeowners toward performance-based audits and retrofit solutions, a RECO which provides several good and cost-effective prescriptive retrofit choices makes the ordinance more workable for all concerned. This approach also helps make the requirements easier for homeowners who don't want to pay the $700 to $900 cost of a HERS 2 rating which, by itself, does not produce any energy savings.

Recommended Retrofit Measures

Mandatory Features

- Low flow toilets, showerheads and faucet aerators
- Hot and cold water pipe insulation at least 5 feed from the water heater
- Exterior door weather-stripping
- Fireplace closures
- Duct repair (if tested duct sealing is not a part of the selected compliance option)

Compliance Options

The homeowner chooses any one of the following four retrofit options:

Prescriptive Approach

1. Air sealing + R-30 roof/ceiling insulation (if < R-13 existing roof/ceiling insulation)
2. Air sealing + duct sealing (if existing forced air heating system)
3. Air sealing + R-19 raised floor insulation (if no existing raised floor insulation)

.. or ..

Performance Approach

4. HERS 2 audit and rating on the existing house, and any combination of retrofit measures which improve the HERS score $\geq$ 10% or achieves a rating of $\leq$ 120.

Cost Cap

- If a remodel ≥ $50,000, there is no cost cap on compliance.
- If a point-of-sale, there is a cost cap of 1.0% of the sale price of the property. If the homeowner demonstrates that no compliance option can be completed for less than the cost cap, a less stringent compliance option (to be determined) shall be allowed.
- If date certain (e.g., all older homes by a fixed future date), there is a cost cap of 1.0% of the assessed property value. If the homeowner demonstrates that no compliance option can be completed for less than the cost cap, a less stringent compliance option (to be determined) shall be allowed.

While the RECO measures recommended here are similar in some ways to Berkeley's proposed revised RECO (scheduled for adoption this fall), there are several differences:

- Hayward mandatory measures required in all homes is a list of low cost items that may be identical to Berkeley's, and similar to the mandatory items contained in the San Francisco RECO.

- Hayward prescriptive options include the one Berkeley prescriptive option – Air Sealing and R-30 Attic Insulation – but it also provides two more: Air Sealing and Duct Sealing; and Air Sealing and R-19 Raised Floor Insulation.

- The Hayward performance option as we recommend it would require both the HERS 2 rating and combined home energy improvements to reduce the HERS 2 score of the existing house by at least 10%; while the proposed Berkeley RECO requires only the HERS 2 rating without any requirement to actually perform any further energy upgrades (aside from the mandatory measures).

While we suggest having a robust performance option as part of the Hayward RECO, we do not recommend pushing homeowners toward a performance path yet until a few important HERS 2 software limitations are addressed and the HERS rating is shown to be working somewhat better.

Triggers

Remodels that cost ≥ $50,000 are appropriate candidates for RECO compliance. Since many alterations and additions already include upgrades for attic and/or raised floor insulation, the extra cost for air sealing and the few mandatory measures might be in the range of $1,500 to $1,800 without incentives. It seems fairly straightforward that any RECO would, at a minimum, include remodels as a basic trigger.

Point of Sale, despite strong opposition by the real estate community, has significant advantages that should be considered. Transfer of title is a clear trigger event that can be

tracked during the grace period for the buyer within which the RECO requirements should be met. A grace period (time after sale) of up to 3 years may take pressure off buyers and real estate agents negotiating a sale, especially if the City allows the resale of the property within the grace period without RECO compliance.

The inherent challenges of a Date Certain RECO are significant, but a strategic approach to implementing this trigger also includes the many advantages discussed above. A suggested refinement to this approach is to require compliance only of older (e.g., pre-1978) homes by, for example, 2021 or 2023.

Appendix A. Analytic Method

The methods and data applied in this study use several steps and components that are more likely to give reliable results than other energy analysis and cost-effectiveness studies done to evaluate a RECO ordinance. This increased level of certainty is due to several factors:

(1) The fact that it is possible to establish a reasonably accurate profile of what existing conditions and energy-related features and efficiencies comprise an average Hayward home.

(2) The ability to calibrate annual space heating calculated by the HERS 2 software to three full years of actual utility data used to disaggregate space heating from the remaining natural gas use (e.g., domestic hot water and miscellaneous); and use the actual unit cost of natural gas paid by Hayward homeowners.

(3) The use of current home energy retrofit cost data for specific retrofit measures in the Bay Area, including data related to retrofits of smaller homes typical of Hayward.

(4) The use of data from City staff to help identify the number of homes with key attributes or systems (e.g., attic vs. non-attic roof, central furnace vs. wall heater).

(5) The "*California Statewide Residential Appliance Saturation Study", Final Report Executive Summary* from June, 2004 (the "RASS" study), CEC Consultant Report 400-04-009 which fills in a few holes in the Hayward-specific data.

The new HERS II software appears to be generally working well in taking energy audit field data and producing a relative rating of home efficiency based the specification of energy features independent from occupant behavior. Based on three decades of reviewing computerized energy simulations of buildings and monitored energy data in the mild Bay Area climate, relative performance of different home retrofit measures as calculated by the HERS II software generally produces expected results.

However, the beta version of the program used was lacking in a few capabilities that we uncovered and that initially required special modeling techniques to overcome. The most significant of these, specifying pre- and post-retrofit duct leakage, was corrected as a result of Gabel Associates bringing this problem to the attention of the California Energy Commission and to EnergySoft, the author of EnergyPro. EnergyPro v5.1.3 now includes this capability. We also noticed what appears to be a difference in the HERS 2 calculation as compared with Micropas 8.1 in modeling an un-insulated single story house with an attic in Climate Zone 3 (Hayward) and comparing it to the same house with R-30 attic insulation. HERS 2 is indicating an 8.5% reduction in space heating, while Micropas 8.1, the other state-approved 2008 Title 24 performance software, is projecting a 14.7% reduction. Based on a review of other data and analytic methods, we decided to use the 14.7% improvement in the results shown in Section 5.

The following approach has been used to estimate energy savings, energy cost savings and the amount of reductions in greenhouse gas emissions (CO2-e) for the average Hayward single family house, and energy efficiency retrofit improvements to the base case:

(1) A 1,292 square foot existing 1-story house is modeled with the latest HERS 2 (see below) Rating (CHEERS) software in EnergyPro v5.1.3. The house size is selected to align with the average Hayward home size according to Zillow.com data.

(2) Annual natural gas usage in therms for space heating and domestic hot water calculated by the HERS 2 energy model is normalized by (a) average natural gas usage for single family homes in Hayward provided by PG&E; and (b) typical values for water heating and miscellaneous (e.g., cooking) natural gas use from the RASS study. Because a relatively small percentage (e.g. 10%) of Hayward homes have air conditioning, electricity use the base case and cooling energy savings from retrofit measures are not included.

(3) An Average Base Case is used to test the energy performance and energy savings of both individual retrofit measures and specific combinations of retrofit measures; and an un-insulated attic base case is used to look at the incremental energy savings starting with an old house with no insulation.

Average Base Case Model

The average base case model is a 1,292 square foot, 1-story existing house assumed to have a standard width of 25 feet, an 8' ceiling height, and a total 16.2% glazing to floor area ratio. The latter value was derived from the Gabel Associates database of existing homes described below, with each orientation (North, East, South, West) containing one-quarter of the total glazing to average orientation effects. Gross wall area, based on the above defined aspect ratio, is also equally divided by orientation.

Existing Roof/Ceiling, Wall, Raised Floor and Windows

Existing roof/ceiling, wall, floor and window conditions in the model are assumed to be the average U-factor calculated from a data survey of 200 existing houses in Gabel Associates archives of recent projects completed in Climate Zone 3 from Title 24 analyses as follows:

Roofs/Ceilings:	U-factor = 0.071 [equivalent to R-13 nominal attic insulation]
Exterior Walls:	U-factor = 0.334 [equivalent to no insulation]
Raised Floors:	U-factor = 0.097 [equivalent to no insulation w/ crawl space]
Windows:	U-factor = 1.01; SHGC=0.73 [equivalent to single pane wood windows]

Although the nominal existing roof/ceiling U-factor for existing homes was determined to be 0.071 from the Gabel Associates database of existing home projects, this value is increased to 0.109 to account for a reduction in overall effectiveness from insulation gaps and reduced insulation thickness from settling of loose insulation and/or compression of batt insulation. This is probably a relatively conservative value given the generally poor quality of insulation installation common in existing attics as observed by home performance contractors.

Retrofit insulation upgrades are modeled as meeting the Quality Insulation Installation criteria in the current Title 24 standards, and having that verified by a HERS 2 Rater or BPI-certified installer.

Building Leakage and Air Sealing

A pre-retrofit air change rate per hour (ACH) of 1.0 is converted in the HERS 2 software to a Specific Leakage Area (SLA) value. Assuming an 8 ft. ceiling height, 1.0 ACH is equivalent to an SLA = 10.18. Post-retrofit ACH is assumed to be 0.5, equivalent to an SLA = 5.09.

Existing HVAC and Water Heating Systems

The existing heating system is assumed to be a forced air furnace with an AFUE = 75%. Ducts are assumed to be in the crawl space with duct insulation of R-2.1. Duct leakage is discussed below.

The existing water heater is assumed to be a tank gas water heater of 30 to 50 gallons, with an Energy Factor (EF) = 0.525 and no hot water pipe insulation. This EF value was the minimum efficiency heater allowed to be sold in the U.S. in the 1990s and 2000s.

Duct Leakage and Sealing

Existing duct leakage is assumed to average 34%. After duct sealing and testing, duct leakage value are assumed to be reduced to 14%. The 20% differential is appropriate in that home performance contractors claim that they can consistently reduce duct leakage down to even lower than 14% in a large percentage of existing homes.

Hayward Utility Data and RASS Study

PG&E provided 2007, 2008 and 2009 data on the monthly and annual natural gas use of all 29,116 single family and duplex dwelling units (as of 2009). Total gas annual? use was 469.8 therms, and the average unit price was $1.104/therm. A baseline gas use was calculated from the lowest monthly value representing a combination of water heating and miscellaneous use (e.g., gas range/oven, gas clothes dryer). The annual baseline gas use was 240.7 therms, so annual space heating is assumed to be the difference which is 229.1 therms. Total annual space heating predicted by the HERS 2 energy model for the 1,292 sf Average Base Case has been calibrated to 229 therms to establish the incremental energy savings of each of the retrofit measures studied and modeled.

The RASS study confirms the relative amounts of different natural gas use, and puts the annual miscellaneous gas use for small older homes at around 38 therms. Annual water heating is then assumed to be around 203 therms.

Figure 12 of the RASS study indicates that 15% of space heating in the mild coastal areas in PG&E territory is provided by some form of electric heat such as permanent or plug-in electric resistance space heaters. If all space heating were gas source, this would mean that the annual gas space heating use would be 229.1 / 0.85 or 269.5 therms.

Annual energy cost savings shown in the results are conservative because electric heating has a much higher cost per unit of heat delivered than natural gas. The average Hayward home which meets 15% of its annual heating load with electric space heaters will pay $351/year total for gas and electric space heating (assuming same $1.104/therm for natural gas and $0.17/KWh electricity). The same house with only gas space heating will pay $298/year or $53/year less without the electric heating.

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Appendix B. Detailed Cost Data

Section 3 provides an overview of the approach used to gather cost data for the various retrofit measures. This appendix provides more specific data on the information obtained.

Cost Data Set A

Three home performance contractors were asked to complete a spreadsheet to determine specific costs for defined energy retrofit measures in a 1,000 sq.ft. and 1,500 sq.ft. home. For each, they were asked to input a "Typical Low" and "Typical High" value. The low value "represents relatively easy access, simple construction and architecture, and no special [installation] issues". The high value "represents more difficult access and/or more challenging existing conditions".

According to the real estate web site Zillow.com, the average single family home in the City of Hayward is calculated as 1,292 square feet. From the above data, a spreadsheet has been developed which interpolates values between the 1,000 sq.ft. home and 1,500 sq.ft. home data points. This adjusted cost data for the average Hayward home is shown in Table A-1.

Cost Data Set B

More general data gathered recently from five Northern California home performance contractors has been compiled to fit – somewhat roughly in a few instances -- within the same spreadsheet matrix as shown above. Because this data has been shared with Gabel Associates indirectly through a major utility company, the data remains anonymous and cannot be verified as to precisely what, in each case, is the installed condition it represents. These cost estimates are somewhat lower than those in Cost Data Set A perhaps because this cost data includes firms which operate outside the Bay Area and, as a result of lower overhead, may be able offer lower home retrofit prices.

Although no specific home conditioned floor area was included in these submitted costs, the assumption for this information is that it applies to older existing homes. According to an August, 2008 report ("*Meeting AB 32 – Cost-Effective Green House Gas Reductions in the Residential Sector"* by Consol for the California Homebuilding Foundation), California homes built prior to the 1970s average less than 1,500 sq.ft. (Table A-2).

Table A-1. Cost Data Set "A"

Upgrade Energy Measures	Interpolated Values for a Hayward 1292 sf 1-Story Home		
	Typical Low ($)	Typical High ($)	Average ($)
Blower Door Test In; Air Sealing w/ caulking, foaming, weather stripping, and thermal bypass mitigation; Test Out w/ BPI compliance Combustion Safety test & CO alarm (if needed)	$1,496	$2,168	**$1,832**
R-30 Attic Insulation (from no insulation)	$1,234	$1,492	**$1,363**
R-30 Attic Insulation (from nominal R-11)	$1,056	$1,299	**$1,178**
R-38 Attic Insulation (from no insulation)	$1,589	$1,981	**$1,785**
R-38 Attic Insulation (from nominal R-11)	$1,292	$1,680	**$1,486**
R-38 Attic Insulation (from nominal R-19)	$1,214	$1,607	**$1,411**
Duct repair and sealing: accessible crawl space	$1,089	$1,705	**$1,397**
Duct repair and sealing: accessible attic	$856	$1,395	**$1,126**
New 40 gal Water Heater, EF=0.58	$1,200	$1,600	**$1,400**
New 40 gal Water Heater, EF=0.62	$1,450	$1,800	**$1,625**
R-13 Wall Insulation (from no insulation): Blown In Cellulose or Fiberglass[1]	$2,450	$3,278	**$2,864**
R-19 Raised Floor Insulation (from no insul.)	$1,098	$2,111	**$1,605**
R-30 Raised Floor Insulation (from no insul.)	$1,594	$2,649	**$2,121**
Air Sealing + R-30 Attic Insulation (from no insul.)	$2,730	$3,660	**$3,195**
Air Sealing + R-30 Attic + Attic Ducts Sealed	$3,586	$5,055	**$4,321**
Air Sealing + R-38 Attic Insulation (from no insul.)	$3,086	$4,149	**$3,617**
Air Sealing + R-38 Attic + Attic Ducts Sealed	$3,942	$5,544	**$4,743**

Note 1: Assumes all work done with holes drilled through drywall from the interior, but excluding the cost of interior repainting.

Table A-2. California Average House Size by Decade

Decade	Average House Size (square feet)
1950s	1402
1960s	1495
1970s	1654
1980s	1819
1990s	2116
2000s	2367

From "*Meeting AB 32 – Cost-Effective Green House Gas Reductions in the Residential Sector*" by Consol for the California Homebuilding Foundation: August, 2008 report.

Cost Data Set B values placed into the previous spreadsheet framework looks as follows:

Table A-3. Cost Data Set "B"

Upgrade Energy Measures	Cost Data Set "B" Typical Existing Home		
	Typical Low ($	Typical High ($	Average ($)
Blower Door Test In; Air Sealing w/ caulking, foaming, weather stripping, and thermal bypass mitigation; Test Out w/ BPI compliance Combustion Safety test & CO alarm (if needed)	$899	$1,080	**$990**
R-38 Attic Insulation (from no insulation)	$1,438	$1,713	**$1,576**
Duct repair and sealing: accessible attic	$796	$1,065	**$931**
Air Sealing + R-38 Attic Insulation (from no insul.)	$2,337	$2,793	**$2,565**
Air Sealing + R-38 Attic + Attic Ducts Sealed	$3,133	$3,858	**$3,496**

Table A-4 shows a comparison of the two different Cost Data Sets:

Table A-4. Comparison of Cost Data

Upgrade Energy Measures	Comparison of Cost Data for Typical Hayward Home			
	Set "B" Avg.	Set "A" Avg.	Average	Range (+/-) % from Average
Blower Door Test In; Air Sealing w/ caulking, foaming, weather stripping, and thermal bypass mitigation; Test Out w/ BPI compliance Combustion Safety test & CO alarm (if needed)	**$990**	**$1,832**	$1,411	30%
R-38 Attic Insulation (from no insulation)	**$1,576**	**$1,785**	$1,681	6%
Duct repair and sealing: accessible attic	**$931**	**$1,126**	$1,029	9%
Air Sealing + R-38 Attic Insulation (from no insul.)	**$2,566**	**$3,617**	$3,092	17%
Air Sealing + R-38 Attic + Attic Ducts Sealed	**$3,497**	**$4,743**	$4,120	15%

The two sets of cost data show a large range in cost estimates for air sealing and testing, but relatively consistent cost estimates for attic insulation and for duct repair/sealing and testing. This may be as a result of a large range of the types of specific causes that result in air leakage, and a range of estimates by different contractors as to the likely effort involved in reducing the overall air change rate. It isn't precisely known what assumptions for improving air sealing are made by the Set "B" home performance contractors for their cost estimates, and this group may possibly be somewhat less aggressive in their effort and expectation of how effectively they will generally reduce air leakage.